MULTIMEDIA UNIVERSITY ™

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, SESSION 2022/2023

EEL4126 – POWER SYSTEM OPERATION AND CONTROL

(LE)

08 JULY 2023
9.00 AM – 11.00 AM
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This Question Paper consists of four pages including the cover page with four Questions only.

2. Answer **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please print all your answers in the Answer Booklet provided.

Question 1

The following are data pertaining to three units in a plant.

Unit 1: $C_1 = 5610 + 79.20\,P_1 + 0.01562\,P_1^2$ \$/h; Min. = 150 MW; Max. = 600 MW
Unit 2: $C_2 = 3100 + 78.50\,P_2 + 0.01940\,P_2^2$ \$/h; Min. = 100 MW; Max. = 400 MW
Unit 3: $C_3 = 936 + 95.64\,P_3 + 0.05784\,P_3^2$ \$/h; Min. = 50 MW; Max. = 200 MW

What unit or combination of units should be used in order to achieve economic dispatch for a load of 550 MW? Try all the possible combinations and find the optimal dispatch for each feasible combination.

[Hints: You will have 2^n possible combination, where n is the number of generator units in the plant. [You may form a table to summarize your results].

[25 marks]

Question 2

(a) Security constrained optimal power flow could be divided into FOUR categories. Name and explain each of them with aid of figures.

[10 Marks]

(b) A small power system is shown in Figure Q2(b).

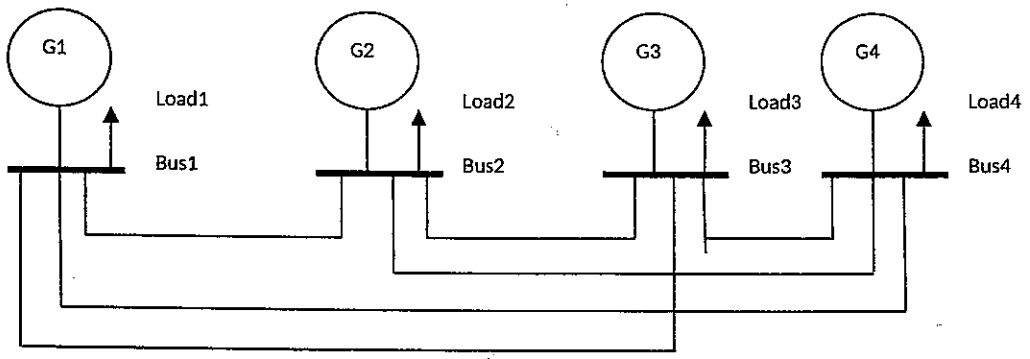

Figure Q2

Line reactances (in per unit) are $x_{12} = x_{13} = x_{14} = 0.1$; $x_{23} = x_{24} = 0.125$ and $x_{34} = 0.167$ on 100 MVA base. Take Bus 4 as the reference bus. The X matrix for DC power flow is computed as

$$X = \begin{bmatrix} 0.0549 & 0.0314 & 0.0333 & 0 \\ 0.0314 & 0.0608 & 0.0333 & 0 \\ 0.0333 & 0.0333 & 0.0667 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

Continued...

(i) Obtain the bus admittance matrix, Y.

[6 marks]

(ii) Calculate the generation shift sensitivity factors, for line 1-2.

[4 marks]

(iii) Calculate the line outage sensitivity factor on line 2-3 for an outage of line 1-2.

[5 marks]

[The line outage distribution factor for line l connected between buses i and j for an outage of line k connected between buses n and m is given by

$$\frac{x_k\left(X_{in}-X_{jn}-X_{im}+X_{jm}\right)}{x_l\left(x_k-\left(X_{nn}+X_{mm}-2X_{nm}\right)\right)}$$

Question 3

(a) Automatic Generation Control (AGC) is the name given to a control system in a power system. What are the THREE major objectives of AGC.

[3 Marks]

(b) Draw a block diagram of an isolated power system consisting of governor, prime mover and rotating mass & load models and explain the functions of each block.

[7 marks]

(c) The fuel-cost function in RM/h of two thermal plants are

$$C_1 = 320 + 6.20\ P_1 + 0.0040\ P_1^2$$

$$C_2 = 200 + 6.0\ P_2 + 0.003\ P_2^2$$

P_1 and P_2 are in MW. The system real power loss is given by

$$P_L = 0.000125\,P_1^2 + 0.0000625\,P_2^2 \text{ MW}$$

The total load is 412 MW. Start with an initial estimate of $\lambda = 7$ RM/Mwh, determine the optimal dispatch and the new value of λ at the end of first iteration.

[15 Marks]

Continued...

Question 4

(a) Explain the functions of an excitation system.

[3 Marks]

(b) Name the type of the controller that commonly used to improve on the dynamic response as well as to eliminate the steady state error. Also, draw and label the block diagram of an AVR compensated with this type of controller.

[7 Marks]

(c) The AVR system of an alternator has the following parameters.

	Amplifier	Exciter	Alternator	Sensor
Gain	9	1	1	1
Time constant	0.18	0.4	1.0	0.05

Draw the AVR block diagram. Compute the closed loop transfer function and the steady state error of the AVR for a step input.

[15 Marks]

End of Paper